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Simulating ECA-AODV Routing Scheme using TCP for MANETs

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Abstract: *ECA model checks different resource constraints before constructing the path. This will ensure long time connectivity between source and destination nodes. TCP model will provide reliable data transfer between source node and destination node, which ensures no data loss and error free. In the current work, end to end ACK scheme is implemented, which will overcome reliability and error issues. In our previous work, the data transfer starts from one of the source, which does not have facility to confirm whether all the information sent is reached to the destination node or not, without any data loss and error free. In the current proposed model, end to end ACK scheme is implemented which will overcome above deficiency.*
When ECA model is combined with QoS parameters in AODV routing process, the simulation parameters improved significantly. A simulation software is developed for testing the performance improvement. The simulation result shows considerable improvement in the TCP scheme as compared to basic ECA-AODV model.
Keywords - *adhoc routing, adhoc wireless networks, Quality of Service (QoS), Event Condition Action (ECA) , ECA Simulation*

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I. Introduction

MANET has self configuring and independent mobile nodes, which will act as router, sender and receiver for data com- munication and are in constant motion. Transmitting information between these types of scenario is a challenging task, since the sender has to find out and construct the path taking care of different QoS parameters and constant movement of the nodes.

AODV is one such routing algorithm which will consider the distance in terms of hop count and the routing queries propagated considering the direction in which the destination node is existing. The algorithm needs to flood the packets and needs to send RREQ to find out the path as well as the destination. The traversing back from destination node will confirm the returning path that will finally reach to the source node. The Event Condition Action model will test the conditions of the next forwarding node before stabilizing that particular link. If all the resource constraints are satisfied then that particular link will be made permanent and RREQ will propagate towards destination. In ECA model, in a particular event, if the condition is satisfied then particular action is executed as described at [1].

1.1 QOS Routing in MANET

We need to consider different QoS parameters such as bandwidth, delay, throughput and delivery probability in the routing decision. The communication algorithm must be designed such that they must preserve minimum required QoS values. In the process of route construction, we need to find out whether sufficient resources are available in the next forwarding node, which will satisfy the minimum QoS requirements.
MANET's have been extensively used for transfer of data generated by different applications. These datas are time bound, security sensitive and needs enormous network resources. For example - Bulky data generated by movie on demand applications, for which enormous resources are needed. In this connection we propose to develop QoS based systems, which ensures reliability with timely delivery of data, maintaining its quality in a higher rate.

1.2 AODV Based QOS Routing

AODV is an on demand reactive routing protocol, which will exchange routing information among neighboring nodes, reduces excessive memory requirements and excessive route discovery. When sending node wishes to send data packets to a destination, then only a route is needed to be established. In AODV, the rate of path convergence is slow compared to flooding technique employed in the link state routing.

1.3 Proposed model for ECA-AODV-TCP model

The ECA based model will check resource constraints before establishing the path between source and destination nodes. This procedure will propagate through intermediate nodes till destination node is reached. To this basic model TCP components are added so that the reliability in the communication process increases.
The basic ECA model has 7 phases, which will guarantee advance resource allocation before communication starts. When this scheme is upgraded using TCP algorithm, then it will provide high degree of flexibility to the dynamic adhoc network. This will cause the change in interaction pattern of the mobile node behavior at runtime. ECA rule enables the dynamic delivery and life cycle management of traffic at runtime.

1.4 Organization of the rest of the paper

The rest of the paper is organized as follows. In the next section, we present related work. In the section 3, reliable routing using ECA model is introduced. At section 4, overall algorithm used in the simulation and RREQ traversing algorithm is presented for TCP model. In section 5, the methodology used in the IO Buffer management is performed. At section 6, simulation flowchart and distance-path construction method is described. At section 7, TCP sliding window which uses selective repeat technique is presented. Section 8 describes simulation parameter, environment and results. The paper concludes with conclusion followed by references.

RREQ	Route Request (Packet)
RSP	Route Response (Packet)
RREPLY	Route Reply (Packet)
RERR	Route Error (Packet)
QoS	Quality of Service
RTT	Round Trip Time

n2n	Node To Node
s2d	Source To Destination
e2e	End to End
RTS	Request To Send (Packet)
CTS	Clear To Send (Packet)

Table 1: Abbrevations

II. Related Work

TCP uses sliding window mechanism to transfer multiple packets in a particular data transfer session. The window size and its congestion effect is studied at [18]. According to this paper each node in wireless adhoc network buffers packets during route disconnection and re-establishment. This is a new mechanism which will reduce the data loss during these activities since no data will be flowing in the network media during state transition period.

The STCP technique [16] will transmit data in multiple paths so that data travelling at least one path will successfully arrive at destination node. this technique will eliminate the need of data retransmission. ECA proramming language [17], where in a particular event, if certain conditions are satisfied then action is executed. These types of systems will receive input events from external envirnoment and react by performing actions that change the stored information. The condition will affect the changed information accordingly. The ECA rules can be expressed using XML also [15] for the semantic web.

Wireless networks are deployed and connected anywhere, anytime and users will exchange information using these adhoc networks [2]. According to this paper ECA scheme based on adhoc on demand distance vector routing protocol for a ubiquitous network is modelled. Adhoc network has applications in real time systems such as hospital environment where measured crititacal parameters such as ECG sensor datas are transmited to the destination computer system, which is located at the monitoring and controlling department. In this centralized system the computation tasks which is required for the incomming data is performed and neccessary actions based on the processing output is taken.

In these types of systems data is transmitted hop by hop basis and requires intelligent routing. ECA pattern based approach is event driven that can be used to model applications and services related to control and management [6]. The ECA model have expensive applications in real time applications such as IOT, where sensors, actuators or any device supporting a TCP/IP layer can be independently be connected with the Internet. According to this paper, ECA pattern based frame work contains device layered service layer where device layer deals with sensors, actuators and controllers that can be used in building management, security, heating and lighting. Service layer functionality is represented as web services.

QoS requirements in adhoc network needs to be fulfilled in order to achieve efficiency in the overall process [9]. Multi- cast network with adhoc property is created and nodes joining the network is based on sustainability of QoS. This paper presents perfomance evaluation with regard to session and packet level QoS criteria. Delay sensitive applications need QoS support in terms of bandwidth and delay. Routing protocols for MANETs are designed to search for shortest path with minimum hop count [5]. This papers proposes a model which ensures that the delay does not exceed a maximum value.

Energy saving is an important issue in any network. AODV-ECA [7] can reduce and balance energy consumption to prolong the network lifetime by switching between different operating states. The nodes need to perform or may be in one of these states of condition test, triggering event and performing action. This will form distributed processing and save lot of energy. [8] describes channal allocation techniques which is needed to communicate with the neighbouring node.

ECA-PC (Event Condition Action - Post Condition) rules [10] helps to manage the events happening at the ubiquitous computing system. In ECA model, policy rule may tell when event occurs in a situation, where conditions is true, then action is executed. These rules are useful to define an algorithm in context-aware applications [11].

ECA rules can be written/implemented in several language such as c, xml [12], android, java [11, 13] etc. These models can be used in systems like database, sensor network, adhoc network, e.t.c.

III. Reliable Routing using ECA model

In our previous work simulation work is conducted for UDP model, where no source to destination (end to end) ac- knowledgement facility is present. In the present work we are adding this very important feature, which will increase the reliability of the network. Additionally the ECA model itself will construct and provide a resource aware route in advance of data transfer.

In our previous work we had following facilities in the model over basic AODV model.

1. Resource aware path constructed dynamically well in advance. 2. Route error will be propagated towards source node when there is link breakage which cannot be corrected with in stipulated time. However the details of data lost will not be informed back to the originating node.

In the current work, in addition to above advantages over basic AODV, we will consider following schemes:

1. The destination node will transmit ACK packet back to the source node when error free packet is received. 2. In case of Error in the packet, it will transmit NACK prompting retransmission of the packet. 3. The source will initiate a timer expectinf ACK/NACK within e2e timeout. If ACK/NACK is not received within timeout, then it will retransmit duplicate packet till *MAX_RET RANSMISSION COUNT* is reached.

IV. Simulation Algorithm

Alg. 1 : Simulation Algorithm

1. Source application generates data
2. Checks route cache for valid source-destination pair
3. If valid s2d pair is present, then send data packet in the already existing path.
4. Otherwise Initiate new RREQ.
5. Search new route towards destination using direction based flooding technique which is based on resource constraint
6. When RREQ reaches to destination, RREPLY packet is created and it will traverse back to the source
7. When the RREPLY is reached to source node then, data is transmitted.

Alg. 2 : RREQ Traversing Algorithm

1. The source node broadcast RREQ packet querying whether the required resources are available at the receiving node.
2. If the resource constraints are satisfied then the node will reply +ve ACK.
3. Otherwise NACK will be replied and source will query next node on random basis.
4. The process(1-3) will repeat until destination node is reached.
5. At the destination RREPLY packet is created and send back to source node confirming the stable route

Data Packet	ACK Packet	Status
0	0	Data loss at media during transmit. Timeout And ReTx
0	1	Not Exists
1	0	Data reached to destination, but ACK is lost- Not reached back to source. Retransmit duplicate packet, but it will be discarded at destination due to duplicate packet reception.
1	1	Ack is received successfully at source node

Table 2: Truth table for TCP transaction

The truth table 2 shows different possibilities of data and ACK packet status in the communication process. 0 in the first two columns entry describes the packet is not reached to the intended destination. 1

indicates that the packet is reached to the destination successfully. If both entries are zeros, then data is lost during transmission and retransmission is required and is requested. This results in global timeout for RREPLY and the data packet is retransmitted. If the data packet column entry is 1 and that of ACK is 0, then data packet is reached to the destination, but ACK is lost in the reverse transmission. In this case global timeout will occur and source will retransmit the packet resulting in reception of duplicate packet at the destination and the packet will be discarded. When data reached to destination and ACK reached back to source within timeout then both safely to their intended destination, then their corresponding entry will be 1.

V. IO Buffer management

The data packets are stored in the intermediate buffers, while the next forwarded node is needed to be decided using route cache. In the simulation input buffer and output buffers are considered. The application uses real time data transfer. So the newer file is important than older file. So when the buffer is full, then older file, which resides in the buffer for longer duration is discarded. Because in the LIVE application strategy, older data/packet is not required and their elimination will not affect the quality of the data received finally at the destination.

VI. Simulation Flow Chart

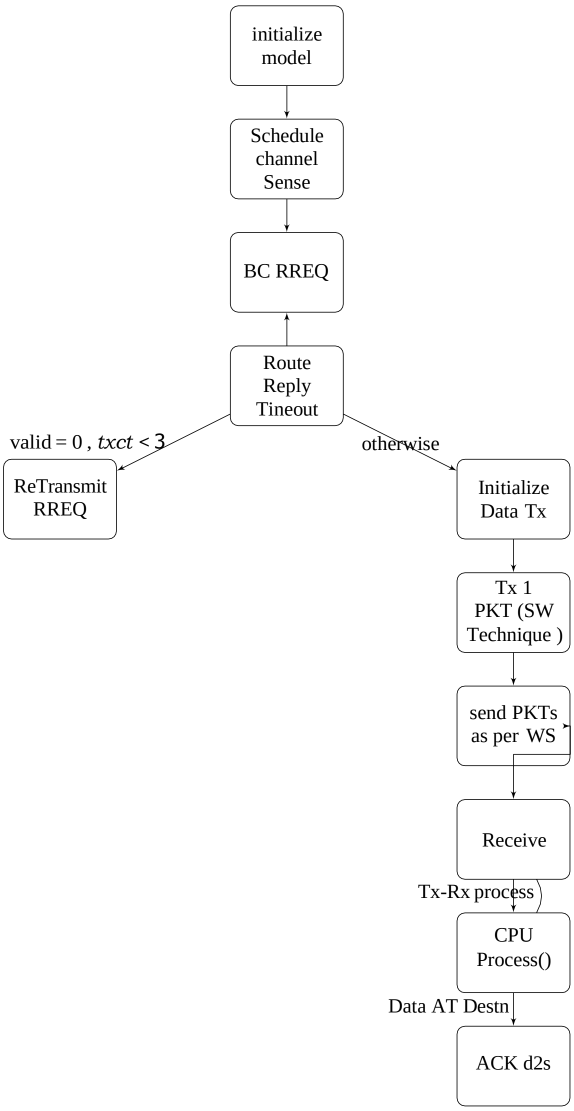

Fig. 1: Simulation Flow Chart

After necessary initialization of parameters , channel sensing procedure is scheduled. When the channel becomes free, then RREQ packet is broad casted and RREPLY timer is started and which will have to wait for

RREPLY.
If valid path is already present, then the data is directly transmitted in that route. Number of *RREQretx* count is checked in case of no RREPLY is received with in timeout. Even after *MAX RREQ ReT x* count exceeds and then if

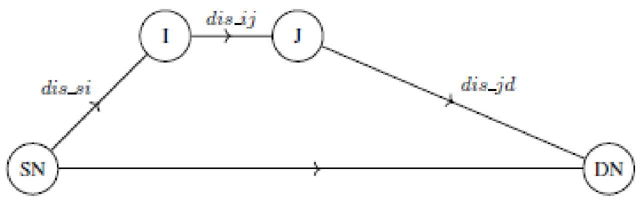

Fig. 2: Distance measurement scenario

Fig. 3: Path construction between SN and DN

no reply is received, then transmission is stopped and ”destination node is unreachable” error message is returned to the application running at the source node.

The data is transmitted according to window size. The data packet will take the route already established. When it reaches to destination, then ACK is generated and is travel back to the source node.

The channel sensed is scheduled for a sampling period of 2 seconds. The necessary events are scheduled on demand basis. The source application will generate data and determines the destination. It will check route cache for a valid entry. If the valid entry is present at the route cache, the same old path is used to transfer data. Otherwise new flooding towards destination is initiated to determine new route. A timer is started waiting for RREPLY. If a suitable QoS con- strained path is not determined within RREPLY timeout, then RREQ packet will be retransmitted. This will continue until *MAX RREQ RET RY* attempts. After this limit, attempt to construct route is aborted and ’destination not reachable’ message is reported to the application running at the source node.

If valid route is newly constructed or already exists, then that route is utilized for sending data packet. So *init trans* is initialized. and the data is transmitted 1 PKT basis. Proper windowing technique is employed in the process. And window timer is used to estimate whether the packets returning +ve ACK or -ve ACK or no ACK before timeout. In the simulation, selective repeat request ARQ is implemented. So only packets which requires retransmission is due to transmission error or lost ACK. Simulation uses piggy backed ACK technique to minimize bandwidth requirements.

When the data packet is transmitted from source, global timer is started to ensure source-destination connectivity. When the ACK will not received even after this timeout duration, then data packet is retransmitted. In the case where no proper ACK is received after *MAX PKT ReT x COUNT* , then the data retransmission process is aborted and same is reported back to the application, running at the source node.

Local connectivity is maintained in the simulation using CTS, RTS signals, which is exchanged before actual data transmission. For this local connection, the CTS, RTS technique is employed before data transmission. Local data ACK facility is used in every intermediate node during data transmission with suitable local timers.

The simulation also take care of local and global error handling routine. Local correction is sufficient if the position of the error is near to the destination, so that the packet will reach to the destination and the global ACK can safely reach back to the source node within global data timeout period. Global correction is necessary when the error location is far from destination node. In this case error message is propagated back to the source node and new route construction is initiated. Since the time consumed in correction and the data packet reaching to destination takes more time than global timeout period.

VII. Distance check criteria

if(*dis ij* < *radio range*) And if(*dis sj* < *dis sd*) then add j into RT(i)
Figure shows distance measurement scenario in the routing table construction process. where
dis si = distance between source node and intermediate node
dis sd = distance between source node and destination node
dis ij = distance between intermediate sending node and intermediate receiving node
dis sj = distance between source node and intermediate receiving node
dis jd = distance between j node and to destination node i = intermediate sender (node)
j = intermediate receiver (node)
ij = link just established / link connectivity currently determining si = multi hop link / route already established

jd = route / link needs to be established SN = source node
DN = destination node
at i , add node(j) into RT(i)

VIII. TCP Sliding window Selective RepeatTechnique

The data to be transmitted is divided into segments in the transport layer, which is required to adjust the data packet size according to network layer router buffer capacity. In the simulation. The window size varies from two packets to 64 packets in multiple of two packets. The number of packet is transmitted according to window size and NACK is expected from receiver. Since the algorithm uses selective repeat technique, only the error/lost packet needs to be retransmitted to the destination.

IX. Simulation And Results

Parmeter	Value
Area Of deployment	1Km * 1Km
Max Speed of Node Mobility	10 m/s
Max Simulation Time	10 Sec
RADIO_FREQ	2.4GHZ
DATA_RATE	10Mbps
SPEED	2*10e8 mps
RT_SRCH_TM	5*10e-6 sec
CPU_SPEED	3*10e6 bps
IN_LINK_BW_10	10*10e6 bps
OUT_LINK_BW_10	10*10e6 bps

MAX_HP_CT	16
BUF_SIZE_INPUT	20 packets
BUF_SIZE_OUTPUT	20 packets
BUF_SIZE_CPU_CACHE	20 packets
RREQ_PKT_SIZE	192 bits
RREQ_ACK_SIZE	64 bits
RREPLY_PKT_SIZE	160 bits
DATA_PKT_SIZE	1024 bits
RERR_PKT_SIZE	160 bits
INIT_ENERGY	10.0 J
RADIO_RANGE	250 m

Table 3: ECA-AODV/TCP - Simulation Parameters

9.1 Simulation Environment

MANET having 100 nodes deployed in random basis over a region of 1Km * 1Km area as shown in the Fig.??. The nodes are allowed to move arbitrarily with maximum speed of 10 m/s in different directions. The deployed nodes will be made to run m number of delay sensitive applications at any given point of time. So in this environment, we develop a quality of service routing by using proposed protocol for the given application.
Both algorithms are simulated in the above deployment for 10 seconds and the trans-receiver circuitry works at operating radio frequency of 2.4GHz. The wireless interface circuit transmits and receives data at the rate of 10Mbps. The data signal will travel in the wireless media (free air) at the speed of 2*10e8 meter per second (mps). The routing table search time (RT_SRCH_TM) is assumed to be 5*10e-6 sec. The input link bandwidth ($IN\_LINK\_BW\_10$) and output link bandwidth ($OUT\_LINK\_BW\_10$) at the interface has bandwidth 10*10e6 bps. The cpu processes the data at the speed of 3*10e6 bps. The IO and CPU buffer can store up to 20 packets at any instance of the simulation. The packet sizes of RREQ, RREPLY, DATA and RERR packets sizes are defined as per AODV RFC. All the nodes are initialized with residual energy ($INIT\_ENERttY$) of 10 Joules(watt-sec). The radio range of all nodes are uniform and is 250m. Each packet in the simulation can cross (MAX_HP_CT) 16 hops. The simulation parameters are listed in the Table 3.

9.2 Results

1. IO Bandwidth :

Fig 5 shows the graph plotted for simulation time along x-axis Vs input Bandwidth (Download) along y-axis The TCP algorithm when applied to ECA-AODV model provides considerable improvement due to controlled traffic and error handling procedure. Similarly Fig 6 shows output bandwidth (Upload) in terms of kbps.
Fig 7 shows the bandwidth percentage utilized, Which shows %ge utilization is the amount of bandwidth used in the communication process. Here download link is considered for analysis.
The percentage is calculated using the formula

$$ge = (max - util/max) * 100 \quad (1)$$

2. Buffer occupancy :

The incoming packets and already processed packets are stored in the IO buffers. The load in the IO buffer is measured at the simulation time instance = 5 sec (middle of the simulation). Since ECA-TCP provides better QoS route, the load at node buffer is low. This will also happen due to the packets are processed in a very fast route. Graphs are drawn for Average 9 and maximum 8 buffer load readings.

3. TCP Window size :

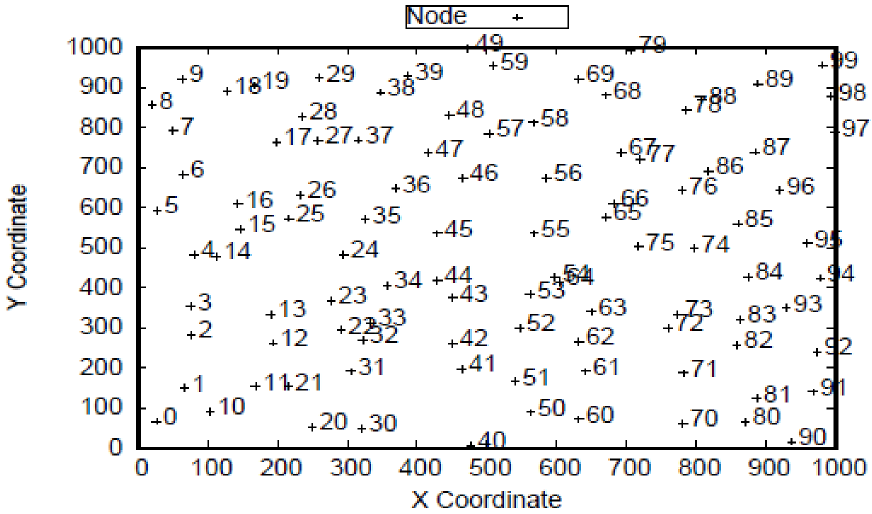

Fig. 4: Deployment

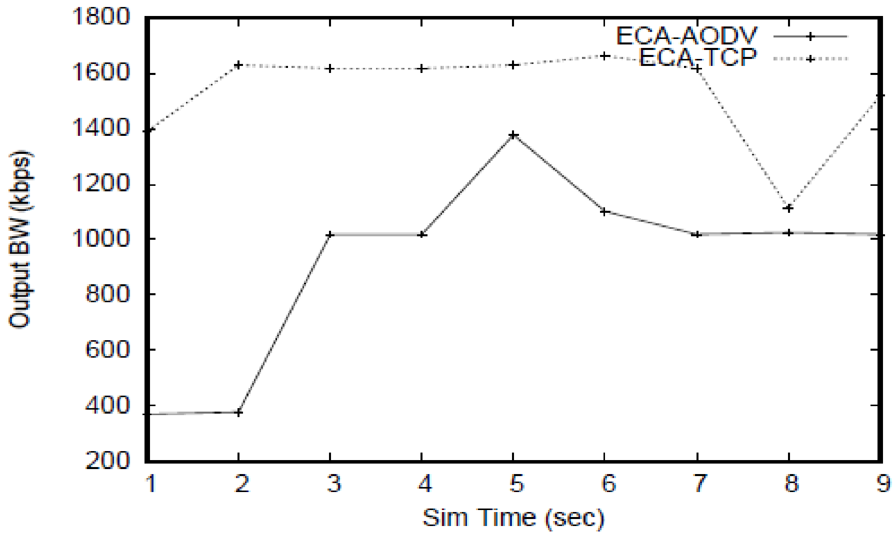

Fig. 5: Input Bandwidth

Fig 10 shows total number of packets dropped in the simulation when TCP window size varies form 1 to 10. When TCP is implemented for ECA-AODV model, the number of packets dropped is significantly reduces due to reliable transmission techniques and advance resource allocation.

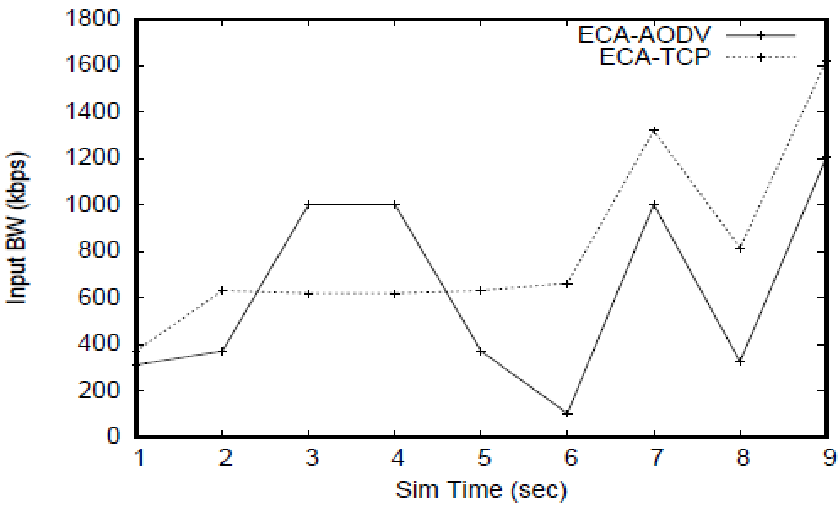

Fig. 6: Output Bandwidth

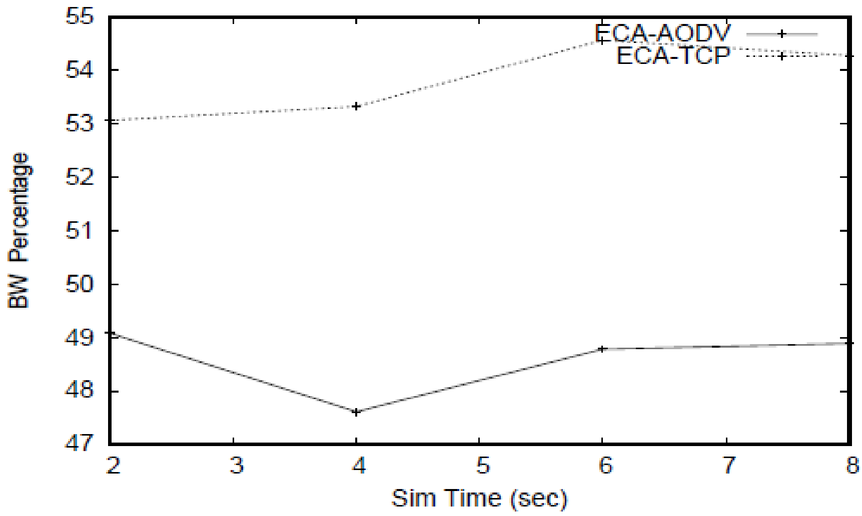

Fig. 7: Channel Utilization

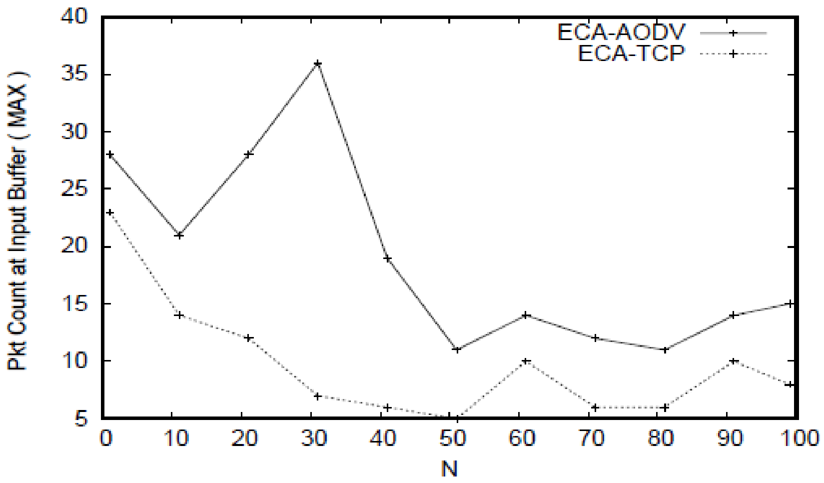

Fig. 8: Buffer Occupancy (MAX)

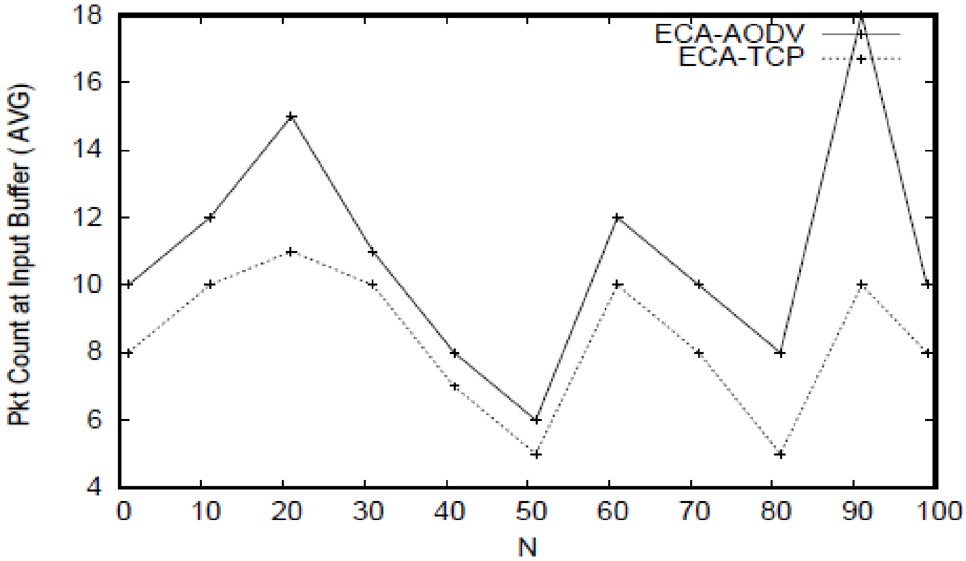

Fig. 9: Buffer Occupancy (AVG)

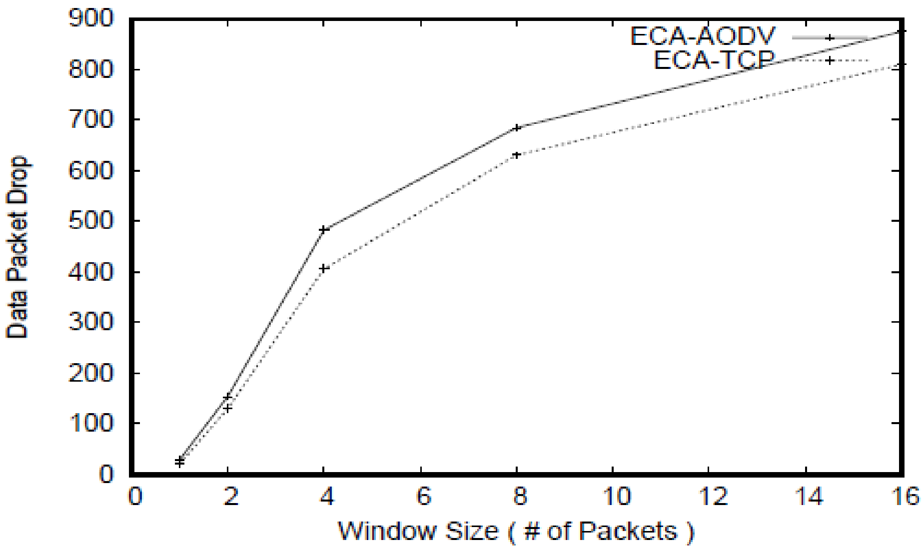

Fig. 10: Effect of Packet Drop Due to Window Size

X. Conclusion

QoS status of the neighboring node is checked before stabilizing a particular link in the RREQ propagation process. This ensures the establishment of reliable, error free route between source and destination nodes. ECA QoS aware model checks the QoS status of the neighboring nodes before selecting the next node to forward the RREQ packet, which will guarantee the establishment of reliable route to the destination. The resulting route, increases the reliability of the data transfer since it satisfies QoS requirements, which constructs a more stable path as compared to original AODV, as it uses normal flooding of RREQ packets without considering any QoS requirements.

The ECA-TCP protocol will provide end to end reliability along with resource constraints and its QoS requirements. A reliable path with advance resource allocation, which satisfy TCP parameters is established between both ends. When TCP techniques are applied to ECA-AODV, the performance of the protocol further improves. The simulation is conducted for different window size and different IO buffer load.

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